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Automatic Switching for Nationwide Telephone Service

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A plan for automatic long distance switching, which will ultimately embrace the entire area of the United States and extend into Canada and perhaps Mexico, has been formulated and important steps have been taken toward its realization. The plan contemplates that when a telephone customer places a call with a long distance operator, this operator will be able to establish a connection to any desired telephone simply by playing a 10 or 11 digit code into an automatic mechanism. She will receive distinctive signals when the called telephone answers or when the telephone or the toll circuits are busy. She will completely control the establishment of the connection and will have available to her the information necessary for proper billing of the call. The plan also contemplates that telephone customers will ultimately be able to dial long distance calls themselves, wherever may be the locations of the calling and called telephones.

INTRODUCTION

Ever since the invention of the telephone 76 years ago, development work has been pressing forward both in telephone transmission and in switching. These two fields have been closely interrelated in the development of telephone service on a nationwide basis, and neither could have progressed as it has without corresponding progress in the other.

The first development of equipment for the mechanical switching of telephone lines was the local dial system to enable one customer to be

connected with another in the same town. It was a natural step to develop the equipment so that operators in nearby towns could complete toll calls through this local dial equipment. This was done first by using the local equipment and then with progressive modifications making it more and more suitable for toll.

By these means through the decades of the 20's and 30's regional networks were developed for operator toll dialing, using step-by-step types of equipment, particularly in Southern California, Connecticut and Ohio. Also many short haul toll calls in metropolitan areas were handled in connection with the panel type dial equipment which was developed for automatic switching in these areas.

Also during this period the range of customer dialing in large metropolitan areas was extended, where local service is measured by message registers, through arrangements for the multiple registration of calls for which the charge was more than one local unit.

An important feature of switching development in this period was the perfecting of "common control" switching systems for large metropolitan areas endowed with a high degree of intelligence and great reliability.¹ As will be shown, still more extensive and complicated functions must be performed by the common control systems of a nationwide automatic switching system.

Also throughout this period great advance was made in the quality and stability of long distance circuits. Telephone connections, some with as many as five circuits in tandem, were being regularly established by telephone operators with satisfactory overall transmission. The limitation was in the speed and accuracy with which multiple switches could be made by operators rather than in the overall transmission characteristics.

Several factors have worked together to bring about a big expansion of long distance telephone service. These include the great growth in the numbers of telephones in service, improvements in long distance transmission, in switching, and in methods of traffic operation. Since automatic switching becomes increasingly attractive as the traffic density increases, this large growth pointed toward the desirability of further mechanizing the switching operations.

In 1943 there was cut into service in Philadelphia the first installation of the No. 4 toll crossbar system.² This system was designed to enable general automatic switching of toll connections in and out of large metropolitan areas and had many of the capabilities necessary for nationwide switching.

The various considerations already mentioned, coupled with the suc-

cess of the No. 4 installation at Philadelphia, led to studies of the service and operating results which might be expected from a nationwide extension of automatic switching. The conclusion was reached that this would be a desirable objective of the Bell System companies and would result in a very substantial further improvement in the speed and accuracy of handling of long distance messages. Accordingly, during the next few years, a national plan was prepared and was adopted by the telephone companies.

GENERAL PLAN FOR NATIONWIDE AUTOMATIC SWITCHING

The features of this nationwide plan and the present status of its application form the subject of the three technical papers which accompany this introductory paper.^{3, 4, 5} The basic requirements to be met in the development of this plan included the following:

1. It should be suitable for the nationwide extension of automatic switching both by originating toll operators and by the customers direct.

When this work was commenced it was clear that a program leading toward general nationwide operator dialing was desirable. Subsequent developments have confirmed the wisdom of making the basic plan consistent with general nationwide customer dialing as well since it now appears that a very wide extension of this form of service will become desirable.

2. The plan must provide for satisfactory overall service between any two telephones in this country and Canada.

Under manual operation satisfactory overall service was provided for by the general toll switching plan in use since about 1930. This plan is modified to recognize the far greater speed and accuracy of automatic switching compared with manual switching. This involves also modifications of transmission design standards so that the overall connections will continue to be satisfactory.

3. The system must be designed for instantaneous service, so that delays due to lack of circuits or equipment would be very infrequent. This is necessary, both from the standpoints of service and the avoidance of tieups, particularly of the automatic switching machinery.

A trunking system must therefore be devised which will most economically meet this requirement, considering overall costs of lines, switching equipment and operation.

4. Machines must be designed for use at strategic points in the network, called "control switching points", to perform automatically the various tasks required to make the overall plan operative and economical.

5. The entire plan must be such as to provide satisfactorily for growth, for flexibility to meet changing conditions and for minimum overall costs of operation.

FUNDAMENTAL PLANS FOR TOLL PLANT

Mr. Pilliod's paper, pages 832 to 850, discusses the fundamental layout of plant for nationwide operator toll dialing. This is subject to changes from time to time with further specific studies, as is the case with all far-reaching fundamental plans of this type. The additional requirements imposed by nationwide customer dialing are still under study as will be discussed a little later.

The national toll switching plan is modified so that there may be a maximum of eight toll circuits switched together to connect any two telephones compared with the previous limit of five.⁶ In order to handle the entire traffic of the country, approximately 100 control switching points are necessary at which highly intelligent common control switching systems of the No. 4 crossbar type will be placed.

A very important feature of the layout is a trunking plan providing for a high degree of use of alternate routes. To design all of the toll circuit groups of the country for a no-delay service would be very expensive. However, taking advantage of the extreme rapidity of automatic switching and the ability to build into the machine capacity for using a large number of alternate routes, a trunking system has been devised in which only about one-sixth of the toll circuit groups of the country need be engineered on a very liberal basis. These are called final groups and are the groups to which the machine ultimately appeals if all of the more direct circuit groups are busy. These more direct circuit groups can then be engineered on a basis providing for high usage of the circuits, recognizing that when one group is busy the machine appeals to another and so on until as a last resort the final group is used.

In determining means for handling all of the toll messages with a relatively small number of control switching points, tremendous advantage was derived from modern transmission developments, particularly carrier systems which give a great economy from the concentration on a long distance route of large numbers of telephone circuits — numbers often running into the thousands. As a result, a considerable degree of circuitous routing and back hauling of circuits is economical if by these means the circuits can be concentrated on heavy routes. This in turn lends itself to a plan using a minimum of control switching points.

NATIONWIDE NUMBERING PLAN

In the previous use of automatic switching by toll operators, the operators were furnished with codes by means of which could be selected the various circuits necessary to reach the destination. These codes were dialed, followed by the local number of the called party. With this system, toll operators calling a given telephone from different remote cities would, in general, use different codes corresponding to the different circuit groups which they must select.

For nationwide toll dialing even by operators this system would have impossible complications, and for nationwide customer dialing it is clear that the code to be dialed must uniquely represent the office which serves the called telephone and that office only and not be dependent upon the route to be followed to reach it. In other words, it involves the development of what is called a destination type code. Another description of this code plan is to say that for toll dialing purposes each telephone in the country (and Canada) must have a distinctive telephone number different from that of every other telephone.

It is also clear that as a practical matter this number should be based upon the local telephone number of the customer prefixed by a minimum number of digits, following easily understood rules.

To bring this about has involved a very high order of planning. Such a plan has been perfected and forms currently the basis for the determination of the coding of all new telephone offices and for changes in office codes when these are necessary. The development of this is the subject of Mr. Nunn's paper.

CUSTOMER TOLL DIALING

When the customer is to dial long distance calls directly without assistance from any operator, two additional requirements are imposed beyond those necessary for nationwide operator dialing.

1. The customer normally is connected to a local central office but for the purpose of nationwide toll dialing he must be connected to the nationwide toll network. At present he does this by dialing a code such as '211' which connects him with the long distance operator. This procedure could be continued. However, since the customer must in any event dial 10 digits for the longest hauls to designate the called telephone, it is desirable if possible to cut out this preliminary step. That would mean modifying the local central office equipment so that it would receive the 10 digit numbers and transmit them on to the toll equipment. This is a simple undertaking for local central offices using the latest

type of local central office equipment, called No. 5 crossbar, which was designed with this in view.⁷ For older types of equipment, the job is more difficult.

2. The switching equipment must be provided with automatic means for recording all of the information necessary for charging the call. In the case of operator dialing this is now done manually by the operator.

Great advances have been made in recent years in the development of automatic message recording equipment. In 1944 there was placed in service in California the first installation in this country of automatic ticketing equipment.⁸ This equipment is associated with step-by-step local switching equipment and automatically prints for each call a ticket similar to that prepared by the operator with manual operation. In 1948 there was installed in Media, near Philadelphia, a greatly improved type of message recording equipment in which the information appears in the form of punched holes in a tape.⁹ This equipment is much more economical than the earlier system and also lends itself to the automatic preparation of toll statements or bills.

The present forms of equipment have been designed to be associated with local central offices. A careful study has been made of their field of application and of the basic plan necessary to provide for a general nationwide extension of customer dialing. This indicates that there will be a large field for automatic message accounting equipment associated with the toll network and arranged to receive orders for toll messages from a number of local dial offices. This centralized AMA equipment, as it is called, is under development and an initial installation will be made next year in Washington, D. C. In this installation the range of customer dialing will be limited and certain service features will be lacking, which it is planned to add later.

The nationwide extension of customer toll dialing involves many operating problems in addition to those relating to the design of the plant. These problems involve the extent to which customers wish to dial long distance calls, requiring 10 pulls of the dial, the accuracy of dialing, the treatment of wrong numbers, provision for giving subscribers information regarding telephone numbers in distant cities, information on charges and many other questions.

Recognizing that the best way to develop these questions is a trial, arrangements were made to open such a trial last fall at Englewood, N. J. This office is equipped with a No. 5 crossbar system so that arrangements for such a trial could readily be made there. The Englewood customers are able to dial directly any of about eleven million telephones in ten metropolitan areas scattered throughout the country, including

Boston, New York, Pittsburgh, Cleveland, Chicago and San Francisco and the Bay area.

The results of this trial have been very encouraging. Subscribers are continuing to dial over 95 per cent of all the calls which can be dialed. Errors due to wrong numbers are at a minimum and other difficulties are relatively low. In so far as this trial can answer the questions, the results are all in favor of the nationwide extension of customer dialing as the development and installation of facilities suitable for this purpose make it possible to do so.

In view of the prospect of nationwide customer dialing, fundamental plan studies are now being made by the Telephone Companies throughout the country of the whole layout of plant including the distribution of centralized automatic message accounting equipments with the future general application of this method of operation. The present indication is that the number of points at which toll operating centers will be required will be greatly reduced. This will react in important ways on the design of telephone buildings, telephone equipment installations and toll circuit routes.

AUTOMATIC TOLL SWITCHING AND ACCOUNTING EQUIPMENT

All of these plans depend upon the successful development of striking innovations in toll switching and automatic message accounting equipments. The plans in turn react upon the features to be incorporated in such equipments and upon the schedule of their development. Mr. Shipley's paper, pages 860 to 882, tells about the more important features of these equipments and the problems which are involved in their development.

CONCLUSIONS

Experience with operator toll dialing shows clearly that it provides a marked improvement in toll service. This improvement will increase as progress is made toward the full application of the nationwide automatic switching plan.

The development of long distance dialing by customers is at an early stage. The results of recent trials, however, indicate that nationwide customer dialing has service advantages and will generally be received with enthusiasm by telephone users. It is anticipated, therefore, that customer dialing will rapidly expand both on a regional and on a nationwide basis.

The service advantages of nationwide automatic switching are not

measured entirely by the increased speed and improved accuracy of connections. An important factor is the continued ability of the telephone system to meet the rapidly increasing demand for telephone service without making excessive demands on the available supply of labor. The development of local dial operation was absolutely necessary to handle the great growth of local telephoning which has taken place. Today, in many places, requirements for people for toll operations are very heavy and an increased amount of automatic toll switching is becoming more and more necessary to make possible handling the rapidly increasing number of long distance telephone messages.

With this development there has been a marked increase of employment. The Bell Companies today employ 244,000 operators compared with 131,000 in 1941. They have also employed many people to build and install about 300-million dollars worth of toll dialing equipment, to construct places to house it, maintain it and carry out operating rearrangements.

With respect to the future, even with the nationwide automatic switching plan in full operation and the local central offices arranged to permit customer dialing, there will still be a large amount of work for operators. They will be required to handle information and assistance traffic, person-to-person calls, collect calls and other classes of calls which do not lend themselves to customer handling, as well as any individual calls which the customers may not wish to dial themselves.

The Bell Companies have necessarily taken the lead in planning and applying these new developments. The plans, however, are all laid in such a way as to include telephone users in Independent Telephone Company offices. The Independent Companies are being kept fully informed of these plans as they develop and are participating, as the development of their own plant makes it practicable and desirable, in extending the benefits of the new forms of operation to their own customers.

This long-term development has required the very close cooperation of all parts of the Bell System - American Telephone and Telegraph Company General Department, Bell Telephone Laboratories, Western Electric Company, Long Lines and all of the Bell Operating Companies. Each installation of equipment and circuits and each operation is a part of a nationwide system and must be closely coordinated. The close interrelation and working together of the various parts of the Bell Telephone System, research and development, manufacturing, engineering and operating are necessary for the effective planning and execution of this tremendous project.

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